IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA,	)	
	)	
Plaintiff,	)	
	)	
v.	)	**Case No. 05-cv-329-GKF(PJC)**
	)	
TYSON FOODS, INC., et al.,	)	
	)	
Defendants.	)	

FEBRUARY 10, 2009 DECLARATION OF ROGER L. OLSEN, Ph.D.

I, Roger L. Olsen, Ph.D., state the following:

1. I have been retained by the Oklahoma Attorney General to provide evaluation, advice and opinions concerning sampling collection, laboratory analyses, and source of contamination in the Illinois River Watershed.

2. At paragraph 93 of Dr. Charles D. Cowan's Rebuttal Report (dated November 26, 2008) he identified an error in my calculation of the PC (Principal Component) Scores. As set out in Section 6 of my Expert Report, Principal Component Analysis (PCA) was conducted using the commercial software program SYSTAT. After the PCA results were obtained using SYSTAT, the PC scores based on these results were calculated by an EXCEL program rather than SYSTAT. This score calculation by EXCEL rather than SYSTAT occurred because SYSTAT could not calculate the PC scores for all samples (SYSTAT cannot calculate scores for samples if some values are missing). The intent was to use log-10 transformed data for the purpose of calculating PC scores. However due to a missing

instruction to save the log-10 transformed dataset, the PC scores were actually calculated using the original dataset before any log-10 transformations.

3. This programming error in the calculation of the PC scores had no impact on the PCA results. The PCA was conducted correctly as intended and the resulting PC loadings and coefficients were correct in all cases. The programming error impacted only the PC score calculation which was performed by the EXCEL program after the PCA was conducted.

4. Because the individual PC scores were not computed correctly, minor corrections are needed to selected figures and tables in my Expert Report. The key figures which are impacted are attached in Attachment A and include: Corrected Figures 6.11-18c and d, 6.11-19a, 6.11-22a, 6.11-23, and 6.11-24.

5. In addition, some text changes are required in my Expert Report. These changes are provided in Attachment B with the changed text shown in red.

6. These errata were made to correct inadvertent errors. My conclusions and opinions are the same.

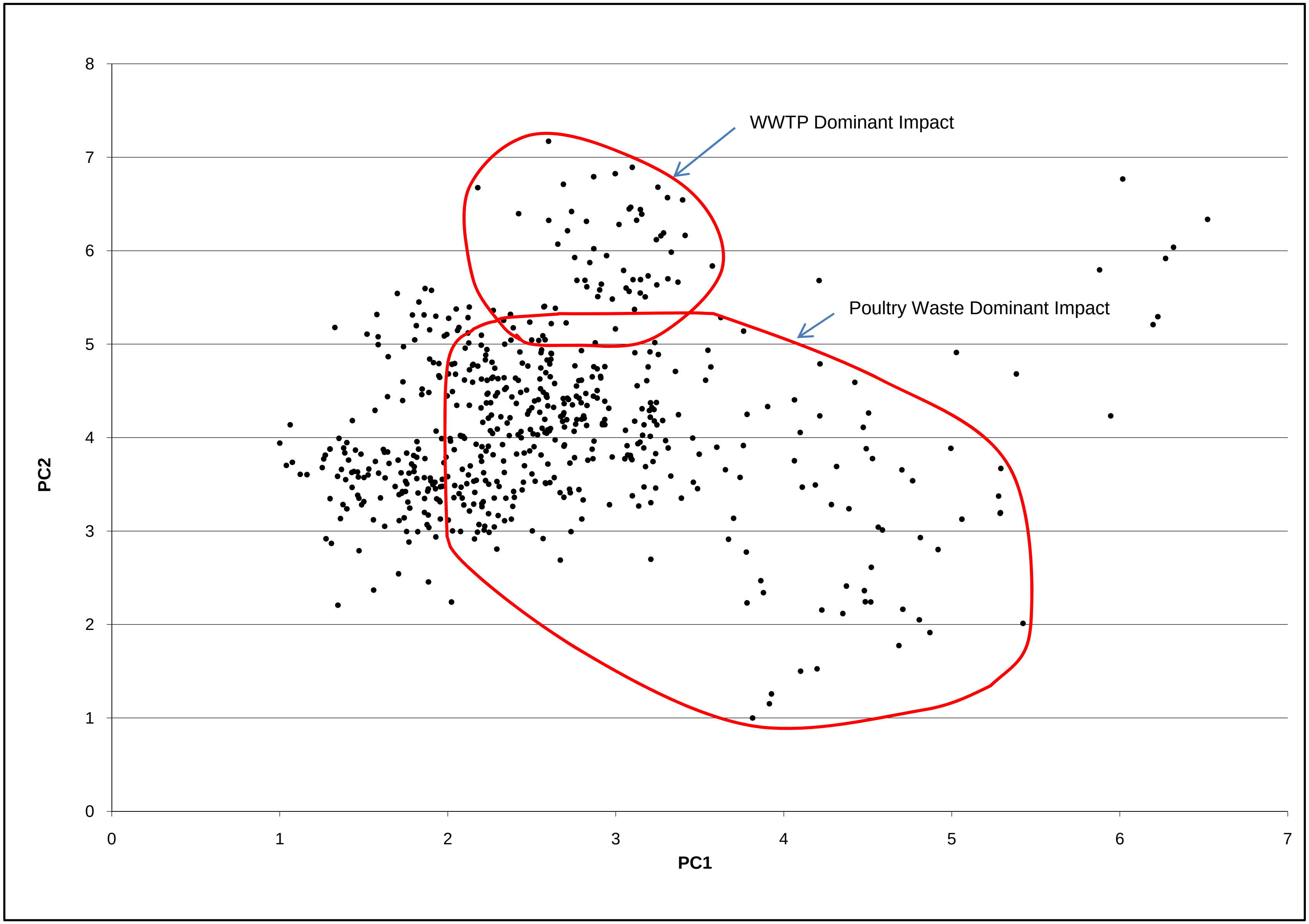
I declare under penalty of perjury, under the laws of the United States of America, that the foregoing is true and correct.

Executed on the 10th day of February, 2009.

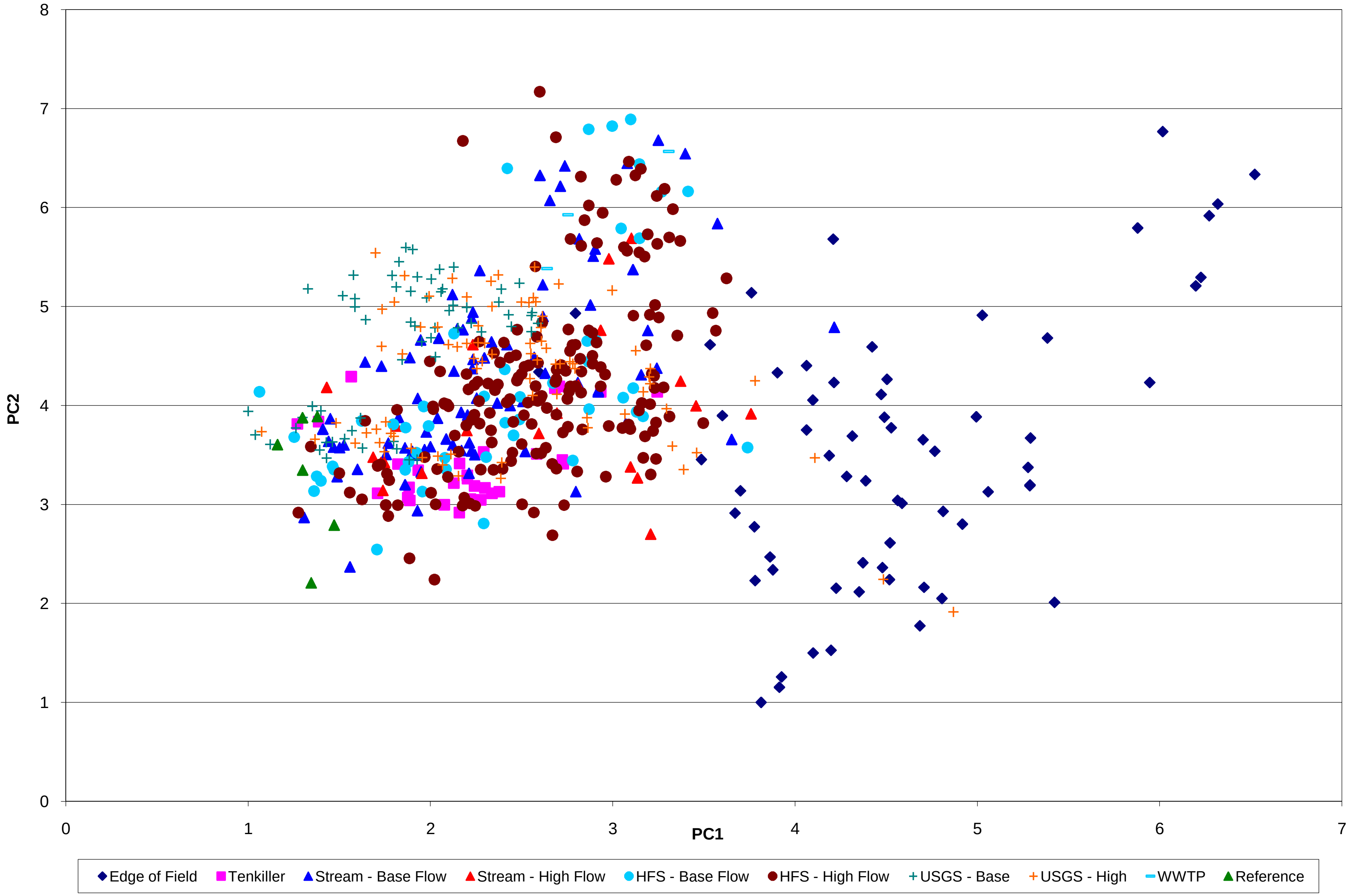
Roger L. Olsen

Roger L. Olsen, Ph.D.

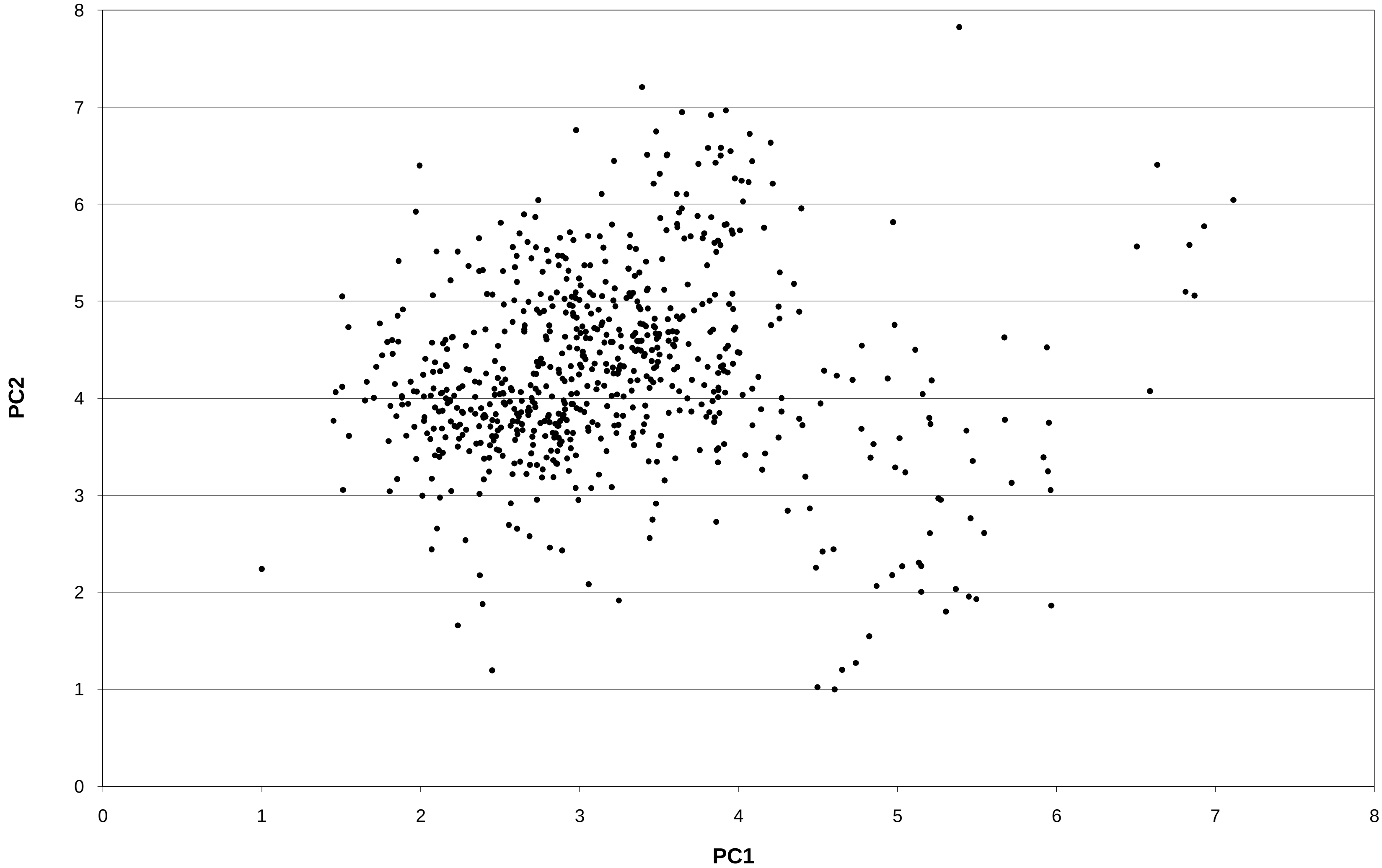
Attachment A
Key Corrected Figures



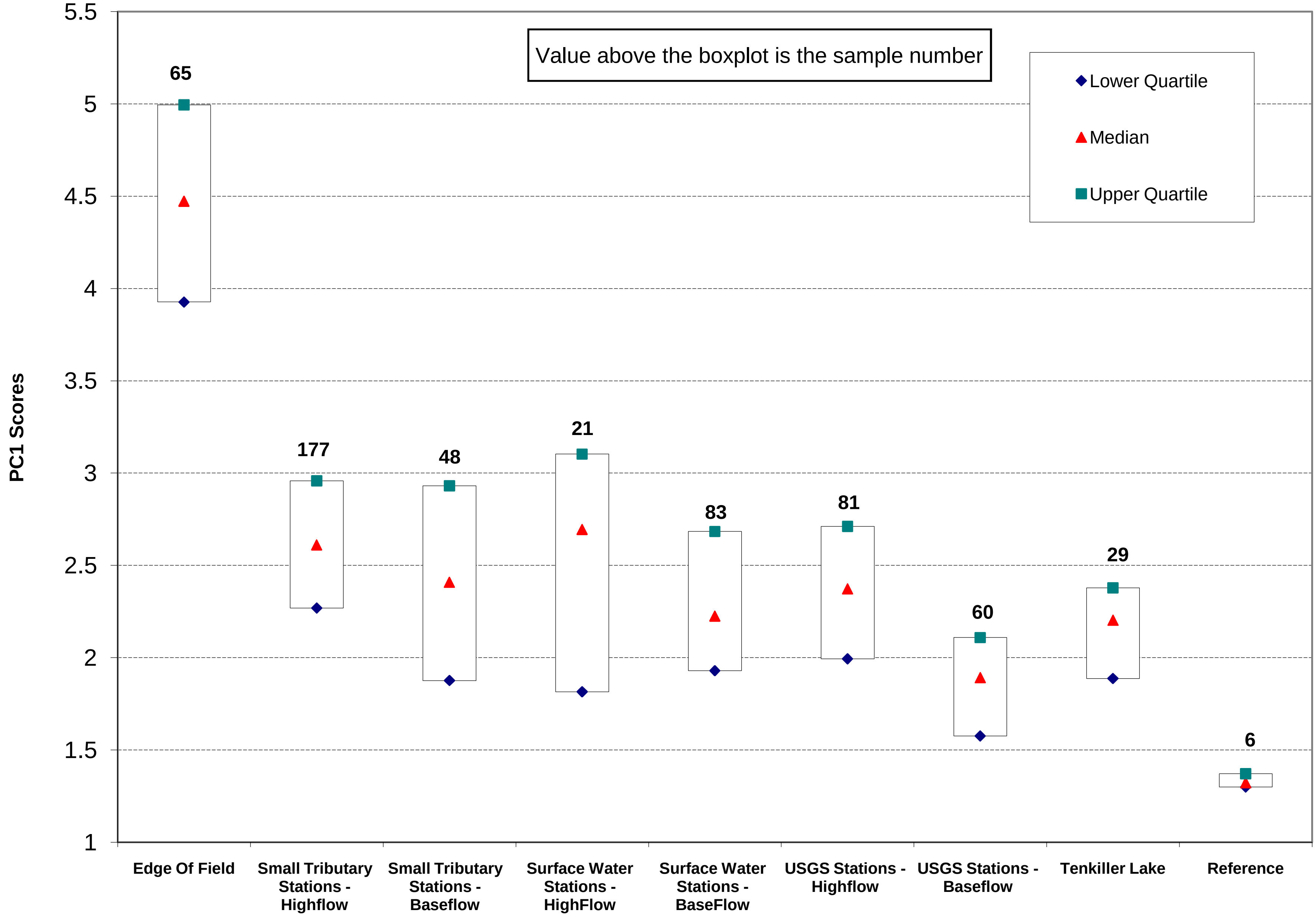
Corrected Figure 6.11-18c
PC1 vs PC2 Scores: Surface Waters (SW3)



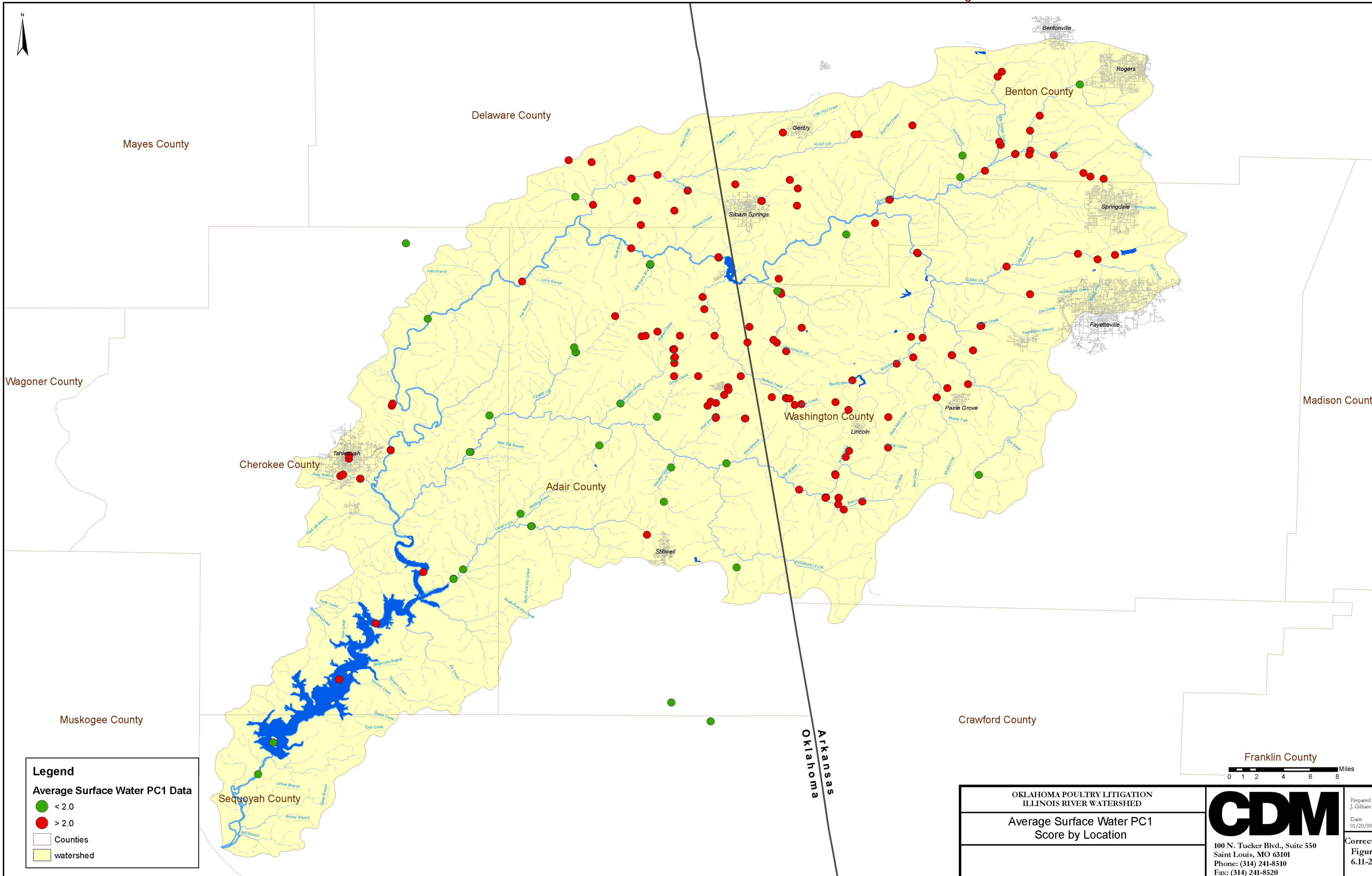
Corrected Figure 6.11-18d
PC1 vs. PC2 Scores: Surface Waters (SW3)



Corrected Figure 6.11-19a
PC1 vs PC2 Scores: Surface Waters, Groundwaters, and Springs (SW17)



Corrected Figure 6.11-22a
Comparison Between Surface Water Environmental Components - PC1 Scores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Lincoln
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Average Surface Water PC1 Data
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Counties
watershed
OKLAHOMA POULTRY LITIGATION
ILLINOIS RIVER WATERSHED
Average Surface Water PC1
Score by Location
CDM
100 N. Tucker Blvd., Suite 550
Saint Louis, MO 63101
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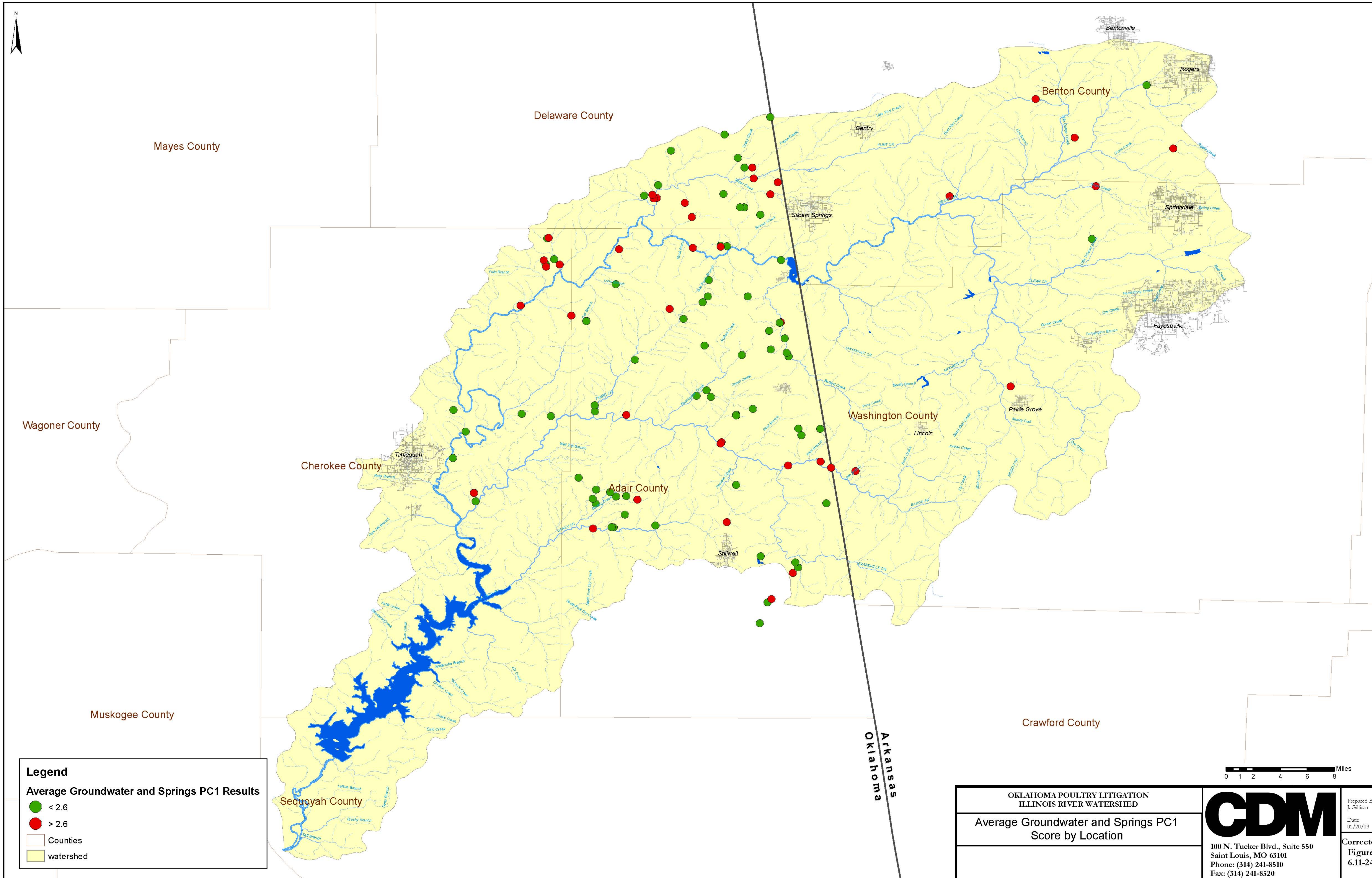
Fax: (314) 241-8520
Prepared By:
J. Gilliam
Date:
01/20/09
Corrected
Figure
6.11-23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watershed
OKLAHOMA POULTRY LITIGATION
ILLINOIS RIVER WATERSHED
Average Groundwater and Springs PC1 Score by Location
CDM
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Prepared By: J. Gilliam
Date: 01/20/09
Corrected Figure 6.11-24

Attachment B
Corrected Text

higher) chemical and bacteria concentrations include: cooper, e. coli, iron, TOC, total P, aluminum, nickel, fecal coliform, enterococcus, total coliform, potassium, zinc, manganese, arsenic, total dissolved P, soluble reactive P, TKN, and barium. These parameters have very high concentrations in runoff from fields with poultry waste and leachate from poultry waste. Table 6.11-10 also show that springs (two samples) impacted with cattle manure have a different composition and lower concentrations than runoff from fields with poultry waste for most parameters including copper, e. coli, iron, TOC, aluminum, nickel, fecal coliform, enterococcus, total coliform, zinc, manganese, arsenic, TKN and nitrite + nitrate.

Figure 6.11-10 shows the loadings for the 26 parameters for both PC1 and PC2 for surface water samples (SW3). As shown for PC1, 22 of the 26 parameters have positive loadings and 17 of the parameters have loadings greater than 0.5. All of these parameters have very large concentrations in runoff from fields with poultry waste and leachate from poultry waste. Figure 6.11-10 also shows the loadings for the 26 parameters for PC2. As shown, 15 parameters have a positive loadings and 7 have loadings larger than 0.5. The largest loadings in order of importance follow: sodium, chloride, sulfate, soluble reactive phosphorus, calcium, total dissolved phosphorus, potassium, magnesium, alkalinity, TDS and nitrite+nitrate. Of these parameters, calcium, sodium, chloride, nitrite+nitrate, and sulfate have larger concentrations in WWTP associated samples then in samples associated with poultry waste.

Because of the chemical and bacterial comparison discussed above, PC1 has been identified as associated with poultry waste and PC2 has been identified as associated with WWTP effluent. These identifications ~~were~~ will be confirmed by the spatial analysis discussed in the next section.

Spatial Analysis

The spatial/temporal analysis evaluated principal component scores in relation to the location of the sample (distance from sources), group type or environmental component (e.g, edge of field), sample conditions (e.g., high flow, base flow), poultry house density, and reference locations.

Appendix F provides the PC1 scores for the surface water samples (SW3). The following observations can be made:

- The highest PC1 scores are the edge of field samples collected as runoff from fields with poultry waste application. Of the top 50 samples with highest PC1 scores (scores above a value of 4.09), 46 are edge of field samples. Three other samples in this group were collected at USGS stations or small tributarties stations during very high flow conditions. The highest PC1 score is 6.5 for an edge of field sample collected after documented poultry waste application and from water flowing off the field. The fact that the highest PC1 scores are from the edge of field samples is consistent with the samples being collected at the source of surface water contamination; i.e., the runoff from fields with poultry waste. These are the locations where the most PC1 parameters were detected at the highest concentrations.

- The lowest scores are from reference areas or areas with minimal poultry houses and operations or large streams (USGS stations) during selected times. The lowest score (1.00) is from ~~REF2 (Dry Creek), the only true reference with no poultry houses in the area~~ USGS-07197000 which was a base flow sample collected on 4/4/07 after a runoff event. ~~Other "reference"~~ Reference locations outside the IRW, REF1, REF2 and REF3 (Little Lee Creek, Dry Creek and Spring Creek) have ~~the third and fifth lowest~~ very low PC1 scores, respectively (1.16, 1.38 and 1.30). Other low scores were from samples collected at HFS30 and HFS28A which are small tributarties in the IRW with low poultry house density. Some low scores were also observed for some USGS stations on the Baron Fork and HFS26. HFS26 has low poultry house density in the actual basin~~, but high poultry house density within a two mile radius~~. If PC1 represents poultry contaminant, then areas with minimal poultry impacts should have the lowest PC1 scores.

- Figures 6.11-22a and 6.11-22b show box plots with the median, lower quartile and upper quartile for the PC1 scores for the following groups: edge of field samples, small tributarties locations with samples collected at high flow, small tributarties locations with samples collected at base flow, USGS stations (at high flow), USGS stations (base flow), surface water samples collected at biological and other river locations (mostly base flow), samples collected in Lake Tenkiller and samples collected at reference or locations with minimal poultry waste impact. As shown the median and upper quartile PC1 scores typically decrease in value in a logical order according to the known pathways from very high at the edge of field to very low at the reference locations. After edge of field samples, samples collected during high flow conditions in the small tributarties and surface waters have the next highest scores followed by base flow samples collected at ~~the same locations~~ the small tributarties and USGS surface water samples collected at high flow conditions. The median PC1 score for USGS samples collected at high flow show an increase compared to the median for base flow surface water samples collected for other river samples. The PC1 scores for samples collected from Lake Tenkiller are higher than the PC1 scores for samples collected at the USGS stations during base flow conditions. The reference areas have the lowest PC1 scores. This evaluation shows the transport of PC1 parameters from the edge of field to rivers and streams and finally to Lake Tenkiller.

Appendix F shows the PC2 scores for run SW3. Several observations can be made:

- Of the highest 65 PC2 scores (above PC2 values of 5.37), three are discharge samples from WWTPs, 56 are surface water samples and 6 are the anomalous EOF samples discussed in Section 6.8. Of the 56 surface water samples, 53 are downgradient of WWTP discharges. This includes 22 samples at HFS04 (downgradient of Siloam Springs WWTP discharge) and 15 samples at HFS22 (downgradient of Lincoln WWTP discharge). Samples from locations 345, 121, 75, 349, 31, 350, 901, 120, 109, ~~72, 122~~ and 246 are also in this group. These samples are downgradient of discharges from Rogers, Springdale, Siloam Springs, Prairie Grove, Lincoln, ~~Westville~~ and Fayetteville WWTP discharges. Most of these samples are downgradient of Springdale or Rogers. See Table 6.11-11 for the largest PC2 scores and locations.

- Of the highest 65 PC2 scores, 6 are from edge of field samples. However the chemical/bacterial compositions of these 6 samples are distinctly different than effluent from WWTPs and are discussed in detail in Section 6.8. These 6 samples also have very high PC1 scores while the WWTP impacted samples do not have high PC1 scores. These 6 samples are not WWTP effluent impacted but are thought to be fresh leachates collected during very high runoff conditions. These samples could potentially contain both cattle manure and poultry waste contamination.

Summary Observations

Because of the spatial analysis and comparisons to waste compositions, PC1 has been identified as related to poultry contamination (i.e., a poultry waste signature) and PC2 has been identified as related to WWTP discharge (i.e., a WWTP signature). In addition, high PC1 scores are observed along the major flow pathways and are higher near sources of poultry waste land application and decrease with distance from the source areas. The evaluation of these observations is performed in conjunction with the next two Steps of the PCA evaluation: step 13 (Use of PC Scores to Determine Sample and Locations Impacted by Major Sources of Contamination) and step 14 (Investigative and Sensitivity Runs).

Step 13: Use the PC Scores to Determine the Samples and Locations in the IRW that are Impacted by Major Sources of Contamination

As previously discussed in Step 12, a spatial evaluation was performed to evaluate the individual sample PC scores in relation to distance from sources, sample group, sample conditions and reference locations. In this step the individual PC scores were evaluated to determine the magnitude of impact or contamination from sources across the basin. If contamination is pervasive and dominant across the IRW in all environment components, a pattern or signature groups of each major source of contamination should be observed when evaluating PC scores relative to each other.

Figures 6.11-18a ~~and 6.11-18b~~ provides a plot of the PC1 (x-axis) vs the PC2 (y-axis) scores for run SW3. Figure 6.11-18a shows all 573 scores ~~and Figure 6.11-18b shows only the scores for the samples inside the box shown in Figure 6.11-18a ("Area of Expanded View")~~. Figure 6.11-18c ~~shows all points in the expanded view area (560 out of the 573 samples are shown). The figure also~~ shows lines around the two major groups of samples identified from PC1 and PC2 evaluations. The group with high PC1 scores is labeled "poultry dominant impact" and contains the samples whose chemical and bacterial composition is dominated by poultry contamination. The group with high PC2 scores is labeled "WWTP dominant impact". These are the samples in which the WWTP impact or influence on the sample is greater than the poultry impact. There are 64 samples in this group (11 % of total). It is important to note that except for some of the reference samples, most of the samples (even those "dominated" by WWTP) show some poultry contamination.

The two groups were selected by examining the locations and chemistry/bacterial composition of the individual samples. For the "WWTP dominant impact" group, the PC2 scores were selected to be above a value of 5.0. As shown in Table 6.11-11, samples below about a score of 5.0 are typically not in locations downgradient of WWTP discharges so cannot be impacted by WWTPs. For the "poultry waste dominant impact" group, a PC1 score of greater than 2.0 was selected. This is a conservatively high value and could have been set lower to include more samples. The value was selected by examining the locations and scores of samples, particularly the scores of reference samples and samples in low poultry density areas. In summary, the samples with PC1 scores below approximately 2.0 include all samples from reference locations (six total), 9 out of 10 samples from HFS30 (small watershed location with low poultry house density) and 7 out of 11 samples from HFS28A (small watershed location with low poultry house density). The one sample from HFS30 and the ~~one~~ samples from HFS28A with higher PC1 scores were collected during extreme or high flow events. Overall, 429 of the 570 samples (75%) had PC1 scores higher than 2.0 and show some poultry contamination.

Figure 6.11-23 shows the average PC1 scores by location (based on PCA run SW3). The average PC1 score was determined if multiple samples were collected and contained in the PCA analyses by calculating the mean score of those samples. In Figure 6.11-23, there are 172 different locations. Of these, 135 have a PC1 average scores greater than 2.0. Therefore, approximately 78 percent of the locations sampled in the IRW show some poultry contamination. Locations with PC1 scores higher than 2.0 are shown in red; those with scores less than 2.0 are shown in green.

The following table gives a breakdown of the number of samples with poultry contamination by the various sample types (based on run SW3):

Sample Type	Sample Counts	Percent > 1.3
EOF	65/65	100
Lake Tenkiller	20/29	70
Steam – base flow	56/83	67
Stream -high flow	14/21	67
Small Trib-base flow	31/48	65
Small Trib-high flow	160/177	90
USGS – base flow	23/60	38
USGS – high flow	60/81	74

Note: the three WWTP discharges samples are not included because they are actual source samples; reference samples are excluded ~~in~~ from the "streams" group.

Evaluation of Groundwater and Spring Samples

Figures 6.11-19a ~~and 6.11-19b~~ shows the PC1 score vs PC2 score plot for PCA run SW17. This run is the same as SW3 except groundwater samples (geoprobe and existing wells) and springs samples are included in the PCA. This results in 699 total samples in the PCA. The results of this run are provided graphically and include:

- Figures 6.11-3 and 6.11-4: Scree Plots and Variance Analysis
- Figures 6.11-12 and 6.11-13: PC Parameters, Loadings and Coefficients

- Figures 6.11-19a, ~~b,~~ c ~~and d~~: PC1 vs PC2 plots

In addition, Figure 6.11-22c provides box plots showing the PC1 scores for geoprobe samples, spring samples and existing well samples (run SW17). As shown, there is a decrease in the median PC1 values with Geoprobe samples having the highest PC1 scores, then springs and existing wells have the lowest PC1 scores. This is a logical progression from shallow alluvial water to springs and to deeper wells.

A similar evaluation of PC1 scores was performed for the SW17 run as for the SW3 run where the PC scores for reference samples and samples from locations in areas of low poultry house density were evaluated. This resulted in determination ~~that~~ of the ~~same~~ threshold PC1 score ~~could be~~ used to determine poultry waste impact (samples with PC1 > 2.6). The locations of the springs, wells and geoprobes with PC1 average values above and below a value of 2.6 are shown in Figure 6.11-24 (based on PCA run SW17). There are 112 locations on the figure and 40 have PC1 values of greater than 2.6 (red dots). These locations are impacted with poultry contamination (36 percent). The following table shows the number of individual samples with poultry contamination (run SW17):

Sample Type	Sample Counts	Percent > 1.3
Geoprobe	12/17	71
Springs	27/49	55
Existing Wells	8/60	13

Overall, 47 out of 126 geoprobe, springs and well samples (37%) show poultry contamination. The three wells known to be greater than 150 ft in depth (actual depth = 203 to 803 ft) did not show poultry waste contamination. One of the grower's wells (unknown depth) did show poultry waste contamination. Sample locations with PC1 scores reflecting poultry waste contamination are located throughout the Oklahoma portion of the IRW (most all sample locations were in Oklahoma) and demonstrate that contamination is widespread for residential wells, springs and alluvial groundwater.

In addition to the samples showing poultry waste impact, some of the groundwater samples have higher PC2 scores than the typical samples identified as being impacted with poultry waste contamination (relatively lower PC2 scores). These groundwater samples potentially show human waste impact. Overall about 2 wells may show potential human impact.

Evaluation of Potential Impact of Cattle Manure

The potential impact due to cattle manure was previously discussed in Section 6.4.2. These mass balance calculations indicate that any impact or contamination from cattle manure would be small (typically < 10 to 15 percent of the mass for most chemical constitutents) compared to the impact due to poultry waste disposal. Previous steps in this subsection (i.e., step 12 discussing waste characteristics) show that cattle manure and cattle manure leachate are very different in chemical composition when compared to poultry waste and poultry waste leachate. Therefore if cattle waste